General Principles for Mechanics Marking

Question Number	Scheme	Marks
1	$T\cos 70^\circ + R = 40g$	M1A1
	$T\cos 20^\circ = F$	M1A1
	$F = \dfrac{3}{4}R$	B1
	Eliminate R and solve for T	**DM**1
	$T = 250$ N or 246 N	A1
		7
	Notes	
1	First M1 for resolving vertically with usual rules (must be using either 20° or 70°)	
	First A1 for a correct equation	
	Second M1 for resolving horizontally with usual rules (must be using either 20° or 70°)	
	Second A1 for a correct equation	
	B1 for $F = \dfrac{3}{4}R$ seen (could be on a diagram)	
	Third DM1 dependent on previous two M marks	
	Third A1 for either 250 (N) or 246 (N)	
2a	$M(D),\ (1080 \times 1) - (400 \times 2) = R_C \times 3.5$	M1 A1
	$R_C = 80$ (N)	A1
	$M(C),\ (1080 \times 2.5) + (400 \times 5.5) = R_D \times 3.5$	M1A1
	$R_D = 1400$ (N)	A1 (6)
	OR $(\uparrow)\ R_C + R_D = 1480$	M1A1
2b	$R_C + (R_C + 520) = 1480$ OR $R_D + (R_D - 520) = 1480$	M1 A1
	$M(D),\ (1080 \times 1) - 400(x - 4) = R_C \times 3.5$	M1 A1
	$x = 2.5$	A1 (5)
		11
	Notes	
2a	First M1 for a moments equation or a vertical resolution	
	First A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation)	

1

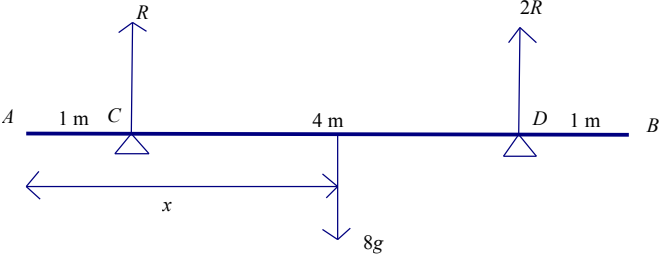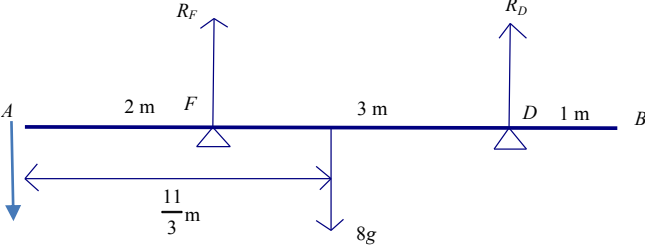| Question Number	Scheme	Marks
	Second A1 for $R_C = 80$ (N) Second M1 for a moments equation or a vertical resolution Third A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Fourth A1 for $R_D = 1400$ (N) Enter marks for equations on ePEN, in the order they appear	
2b	First M1 for a moments equation or a vertical resolution First A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Second M1 for a moments equation or a vertical resolution Second A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Third A1 for $x = 2.5$ Enter marks for equations on ePEN, in the order they appear **N.B.** Equations may contain any or all of R_C, R_D or x for M marks but must contain only **one** of R_C or R_D to earn the A mark. **N.B.** If they assume that $R_D = 520$, they lose all the marks for part (b). **N.B** If they start with $2R = 1480$ and then add or subtract (or both) 520 to their R value, M0**.** **N.B.** If brackets are omitted in a moments equation e.g. $(520 + R_C).4$ is written as $520 + R_C.4$, the M mark can be scored	
3	$8mu - 4mu = 5mv$	M1A1
	$v = 0.8u$	A1
	For P: $\quad -I = 4m(0.8u - 2u)$	M1 A1
	$I = 4.8mu$	A1
	OR For Q: $\quad I = m(0.8u + 4u)$	M1 A1
	$I = 4.8mu$	A1
		6
	Notes	
3	First M1 for CLM with correct no. of terms, all dimensionally correct, to give an equation in m, u and their v only. Condone consistent g's or cancelled m's and sign errors. (N.B. The CLM equation could be obtained by equating the magnitudes of the impulses on each particle) First A1 for a correct equation (they may have - $5mv$) Second A1 for $0.8u$ or $- 0.8u$ (as appropriate) Second M1 for using Impulse = Change in Momentum for either P or Q (M0 if *clearly* adding momenta or if g is included or if different mass in the two momentum terms) but condone sign errors.	

1

Question Number	Scheme	Marks
3.	$(\uparrow)$ $\quad R + 2R = 12g + 3g$ $M(A), \quad 2Rx + 3R = 12g.4 + 3g.8$ $x = 5.7$	M1 A2 M1 A2 A1 **7**
	Notes	
	First M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms) First A1 and Second A1 for a correct equation in R (or S where $S = 2R$) only or R and x only or S and x only. (-1 each error , A1A0 or A0A0) Second M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms) Third A1 and Fourth A1 for a correct equation in R (or S where $S = 2R$) only or R and x only or S and x only. (-1 each error, A1A0 or A0A0) Fifth A1 for $x = 5.7$ oe **N.B. On ePen, first 3 marks are for a vertical resolution, if it appears, second 3 marks are for a moments equation.** **If no vertical resolution, award marks as they appear for the (two) moments equation(s).** **(i)** In a moments equation, if R and $2R$ (or S and $0.5S$) are interchanged, treat as 1 error. **(ii)** Ignore diagram if it helps the candidate. **(iii)** If an equation is correct but contains both R and S, treat as 1 error. **(iv)** Full marks possible if all g's omitted. **(v)** For inconsistent omission of g, penalise each omission. $M(B), R \times 5 + S(8 - x) = 12g \times 4$ $M(C), S(x - 3) = 12g \times 1 + 3g \times 5$ $M(D), R(x - 3) + 3g(8 - x) = 12g(x - 4)$ **N.B. If they use a different variable, other than x, for a length, with it <u>clearly</u> marked on the diagram, they can score all the marks for any moments equation.**	

Question	Scheme	Marks	Notes
2.(a)	$M(C)\,140(a-2)+30(2a-2)=120 \times 4$ $M(G)\,50(a-2)+30a=120(6-a)$ $M(D)\,4\times50+30(2a-6)=140(6-a)$ $M(B)\,140a=120(a-6)+50(2a-2)$ $M(A)\,50\times2+120\times6=140a+30\times2a$	M1	Moments or alternative complete method to form an equation in a only. Dimensionally correct. Condone sign error(s) No missing/additional terms Condone a common factor of g
		A1	At most one error
	$\left(200a=820\right)$	A1	Correct unsimplified equation in a
	$a=4.1$	A1	
		(4)	
(b)	$(\uparrow),\ \left(2R=170=>\right)R=85$	B1	Or a correct second moments equation in their a to achieve 2 equations in 2 unknowns
	$M(A)\,85\times2+85\times x\ =\ 140\times a+30\times2a$ $M(C)$ $85(x-2)=140\times(a-2)+(2a-2)\times30$ $M(G)\,85\times(a-2)+30\times a=85(x-a)$ $M(E)\,30(2a-x)+85(x-2)=140(x-a)$ $M(B)\,85\times(2a-2)+85(2a-x)=140\times a$	M1	Moments equation with equal reactions in a or their a. Dimensionally correct. No missing/additional terms. Condone sign error(s) Accept alternative complete method to form an equation in a different horizontal distance to E Condone incorrect R, $R\neq120, R\neq50$ Condone a common factor of g
		A1ft	At most one error Follow their a and their $R\neq120, R\neq50$
		A1ft	Correct unsimplified equation in AE Follow their a and their $R\neq120, R\neq50$
	$AE=\dfrac{130}{17}$ m (7.6 m or better)	A1	
			If they find a different x, e.g. $CE=5.6$ and go no further, they score 4/5.
		(5)	
		[9]	
			A candidate who has a common factor of g throughout can score 8/9
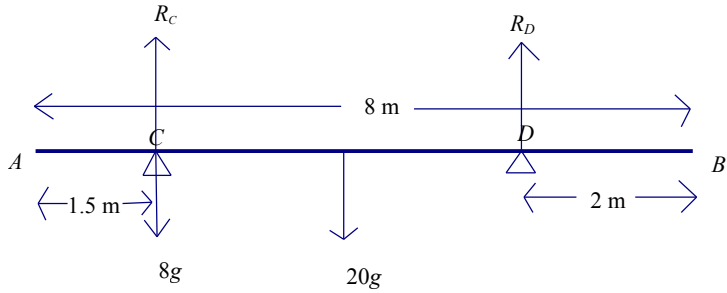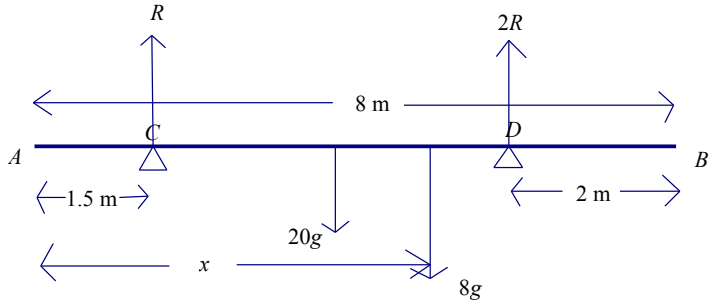
Question Number	Scheme	Marks	Notes
4.(a)			
	$M(A)$ $(30g \times 2) + (50g \times 4) = 0.6\,S$	M1	Moments equation. Requires all terms and dimensionally correct. Condone sign errors. Allow M1 if g missing
	$M(C)$ $(0.6 \times R) = (1.4 \times 30g) + (3.4 \times 50g)$ $M(G)$ $(2 \times R) = (1.4 \times S) + (2 \times 50g)$ $M(B)$ $(4 \times R) + (2 \times 30g) = (3.4 \times S)$	A1	Correct unsimplified equation
	$(\uparrow)$ $R + 30g + 50g = S$ $\quad(R + 784 = S)$	M1	Resolve vertically. Requires all 4 terms. Condone sign errors
		A1	Correct equation (with R or their R)
	NB: The second M1A1 can also be earned for a second moments equation		
	$R = 3460$ or 3500 or $\dfrac{1060g}{3}$ (N) Not 353.3g	A1	One force correct
	$S = 4250$ or 4200 or $\dfrac{1300g}{3}$ (N) Not 433.3g	A1	Both forces correct If both forces are given as decimal multiples of g mark this as an accuracy penalty A0A1
		(6)	
4.(b)	$M(C)$ $(30g \times 1.4) + (Mg \times 3.4) = 0.6 \times 5000$	M1	Use $R = 5000$ and complete method to form an equation in M or weight. Needs all terms present and dimensionally correct. Condone sign errors. Accept inequality. Use of R and S from (a) is M0
		A1	Correct equation in M (not weight) $\left(\text{implied by } M = 77.68\right)$
	$M = 77$ kg	A1	77.7 is A0 even is the penalty for over-specified answers has already been applied
		(3)	
4.(c)	The weight of the diver acts at a point.	B1	Accept "the mass of the diver is at a point".
		(1)	
		[10]	
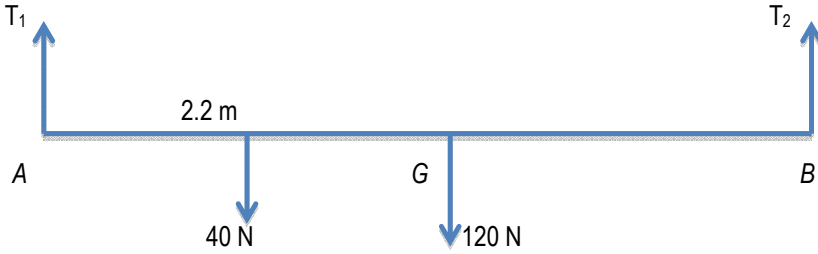
Question Number	Scheme	Marks	Notes
6(a)		M1	Resolve vertically to form an equation in R_c or R_D. All terms required. Condone sign errors.
	$2T + T = 6g + 15g$	A1	Correct unsimplified equation ($R + \dfrac{1}{2}R = 6g + 15g$)
	$2T = 14g = 137$ N or 140 N	A1	
		(3)	
(b)		M1	Take moments - all terms must be present and of the correct structure. Form an equation with one unknown length.
	$M(A)$ $15g\ AX\ +\ 6g \times 2 = (2T \times 1.5) + 4T = 7T$ $M(B)$ $15gd + 6g \times 2 = 2T \times 2.5$ M(c of m) $2T \times 0.5 + 15gd = 2 \times T$ $M(C)$ $6g \times 0.5 + 15g(x - 1.5) = T \times 2.5$	A2	-1 each error. Follow their T NB: Use of the correct reactions the wrong way round is one error. $\left(15g \approx 147,\ \ 6g \approx 58.8,\ \ 12g \approx 117.6\right)$
		M1	Substitute for T and solve for AX
	$AX = \frac{37}{15}$ m $= 2.5$ m (or better)	A1	$2.4\dot{6}$
		(5)	
	NB: If you see parts (a) and (b) merged, award the 8 marks as bM1 for the first moments equation bA2 for the equation correct aM1 for a second moments equation and an attempt to solve for R_C aA1 for the second equation correct aA1 for the reaction correct bM1 and bA1 as above		
(c)	$M(C),\ \ 15g\ YC\ = 6g \times 0.5$	M1	Requires both terms present and of the correct structure. No additional terms (Using $R_C = 21g, R_B = 0$)
		A1	Correct unsimplified equation
	$YC = 0.2$ m	A1	
	$AY = 1.3$ m	A1	
		(4)	See over for Alt (c)
		12	

Question Number	Scheme	Marks	Notes
4 (a)	(i) $M(D)$ $3R_C + 1 \times 3g = 2 \times 4g + 5 \times 2g$	M1	e.g.Take moments about D – requires all 4 terms of the correct form, but condone sign errors. 1x need not be seen
		A1	Correct unsimplified equation
	$R_C = 5g$ or $49\,\mathrm{N}$	A1	
	(ii) $R(\uparrow)$ $R_C + R_D = 4g + 2g + 3g$	M1	e.g.Resolve vertically to form an equation in R_C and R_D, requires all 5 terms
		A1	Correct unsimplified equation
	$R_D = 4g$ or 39 or 39.2N	A1 (6)	
Alt	$M(A)$ $3 \times 4g + 6 \times 3g = 2R_C + 5R_D (= 30g)$	M1A1	Two equations – M1A1 for each
	$M(B)$ $3 \times 4g + 6 \times 2g = R_D + 4R_C (= 24g)$	M1A1	
	$M(C)$ $3R_D + 2 \times 2g = 1 \times 4g + 4 \times 3g$		
	$M(\text{centre})$ $3g \times 3 + R_C = 2R_D + 2g \times 3$		
	$R_C = 5g$ or 49 N, $R_D = 4g$ or 39 or 39.2N	A1,A1	Solve simultaneously for R_C and R_D
(b)	$M(D)$ $3R_C + xg = 8g + 10g$ $(3R_C = (18 - x)g)$	M1	First equation in x and R (or R_C and R_D) – correct terms required but condone sign slips.
	$R(\uparrow)$ $R_C + R_D = 4g + 2g + xg$	M1	A second equation, correct terms required but condone sign slips.
	Alternatives: $M(B)$ $4R_C + R_D = 12g + 12g$		
	$M(A): 2R_C + 5R_D = 6xg + 3 \times 4g$		
	$M(C): 2 \times 2g + 3R_D = 4xg + 1 \times 4g$		
	$2(18 - x)g = 3(6 + x)g$	DM1	Use $R_C = R_D$ and solve for x. (as far as $x = \ldots$) Dependent on the two previous M marks.
	$x = 3.6$	A1 (4)	
		[10]	

Question Number	Scheme	Marks
7a		
	N.B. If R_C and R_D reversed, can score max: M1A1(if vert res is used)M1A0DM1A0 Consistent omission of g in both parts of this question can score all of the marks.	
	Resolve vertically: $3R = 8g$	M1A1
	$M(C)$: $8g(x-1) = 4 \times 2R$	M1A1
	$8gx = 8g + \dfrac{64g}{3} = \dfrac{88g}{3}$, $x = \dfrac{11}{3}$ **Given Answer**	**DM**1A1
		(6)
	N.B. (Allow R_D instead of $2R_C$ in either equation for M mark)	
	SC: $M(G)$: $R(x-1) = 2R(5-x)$ $x = \dfrac{11}{3}$ **Given answer**	M2 A2 **DM**1 A1
		(6)
7b	**N.B.** If they use a value for a reaction found in part (a) in their part (b), no marks for part (b) available.	
	Resolve vert : $R_F + kR_F = 11g$ (Allow R_D instead of kR_F for M mark))	M1A1
	$M(F)$: $(kR_F \times 3) + (3g \times 2) = 8g \times \dfrac{5}{3}$ (Allow R_D instead of kR_F for M mark)	M1A1
	$k = \dfrac{2}{7}$ oe , 0.29 or better	**DM**1A1
		(6)
		[12]

1

Question Number	Scheme	Marks
4a		
	Moments about D: $20g \times 2 + 8g \times 4.5 = R_C \times 4.5$ **OR** Resolve: $R_C + R_D = 28g$	M1A1
(i)	$R_C = \dfrac{152}{9}g \,(=166 \text{ or } 170)$	A1
	Moments about C: $20g \times 2.5 = R_D \times 4.5$ **OR** Resolve: $R_C + R_D = 28g$	M1A1
(ii)	$R_D = \dfrac{100}{9}g \,(=109 \text{ or } 110)$	A1
		(6)
4b		
	Moments about A: $R \times 1.5 + 2R \times 6 = 20g \times 4 + 8g \times x$	M1A1
	Resolve: $3R = 28g$, $\left(R = \dfrac{28}{3}g\,(=91.5)\right)$	M1A1
	Substitute for R and solve for x: $\dfrac{27}{2} \times \dfrac{28}{3}g = 80g + 8g \times x$	M1
	$\qquad\qquad 126 = 80 + 8x, \quad 8x = 46, \quad x = 5.75\,(\text{m})$	A1
		(6)
4c	The weight of the package acts at point C (or E)	B1 (1)
		[13]
	Notes **N.B.** In both parts, enter marks on ePen for the *equations* as they appear **BUT** in part (a) second A1 is for R_C and fourth A1 is for R_D Remember to only penalise overaccuracy, after use of g, ONCE per whole question	

1

Question Number	Scheme	Marks
5(a)		
(i)	$M(B),\ 4T_1 = 120 \text{ x } 1.8 + 40(4-x)$ $T_1 = 94 - 10x$	M1 A1 A1
(ii)	$M(A),\ 4T_2 = 120 \text{ x } 2.2 + 40x$ $T_2 = 66 + 10x$	M1 A1 A1 (6)
(b)	$94 - 10x \le 84$ $x \ge 1$ $66 + 10x \le 84$ $x \le 1.8$ $1 \le x \le 1.8$	M1 M1 A1 both CV A1 (4)
		10

	Notes	
5(a)(i)	First M1 for a complete method to find an equation in T_A and x only. First A1 for a correct equation in T_A and x only. Second A1 for $94 - 10x$	
(ii)	Second M1 for a complete method to find an equation in T_B and x only. First A1 for a correct equation in T_B and x only. Second A1 for $66 + 10x$	
5(b)	First M1 for their $T_A \le 84$ or $= 84$ or < 84 to give equation or inequality in x only. (> 84 is M0) Second M1 for their $T_B \le 84$ or $= 84$ or < 84 to give equation or inequality in x only. (> 84 is M0) First A1 for both critical values of x, 1 and 1.8 SEEN. Second A1 $1 \le x \le 1.8$ or $1 \le x$ AND $x \le 1.8$ or $[1, 1.8]$	

6. (a)	x is greatest when rod is about to tip about B *i.e.* $R_A = 0$ (can be implied)	B1
	$M(B), \ 2W(x - 2l) = W\frac{1}{2}l$	M1 A1
	$x = 2.25l$	**DM**1 A1 (5)
(b)	Use of $R_A = 2W$ in an equation	M1
	$M(B), \ 2W(2l - x) + W\frac{1}{2}l = 2W.2l$	M1 A1 A1
	$x = 0.25l$	A1 (5)
		10

NOTES

Question 6(a)
B1 for x greatest when $R_A = 0$ (usually implied in moments equation) or correct use of $R_A \geq 0$.
First M1 for an equation in x and l ONLY (usually moments about B but could come from two equations). Allow if there is W (uncancelled) in each term. (M0 if R_A term included unless it subsequently becomes zero)
First A1 for a correct equation –again allow even if W has not been cancelled.
Second M1, dependent on previous M, for solving for x in terms of l.
Second A1 for $x = 2.25l$.
N.B. If 'l' omitted consistently and then inserted at end award full marks.
If not inserted then can score max B1M1A0M1A0

Question 6(b) Scheme change

First M1 for use of $R_A = 2W$ in any equation (vertical resolution or moments) or for correct use of $R_A \leq 2W$.
Second M1 for an equation in x and l ONLY (usually moments about B but could come from two equations). Allow if there is W (uncancelled) in each term.
A2 for the equation, again allow even if W has not been cancelled, -1 each error.
Third A1 for $x = 0.25l$.
N.B. If 'l' omitted consistently and then inserted at end award full marks.
If not inserted then can score max M1M1A0A0A0.

Question Number	Scheme	Marks
3.	$M(X)$, $25g(14 - x) + 100g. \, 12 = 2009 \times 6$ $x = 12.8, \, 13 \, (m)$	M1 A1 A1 DM1 A1 **5**
Notes		
3.	First M1 for producing an equation in a relevant unknown length *only*. Usual rules, correct no. of terms, dim correct. (If more than one equation is used, rules apply to *each* equation) First A2 for a correct equation; -1 each error (omission of *g*'s counts as one error) Second DM1, dependent, for solving for AG. Third A1 for 12.8, 13 oe. S.C. If they use *M* in their equation(s) and never find it or just assume a value for it e.g. 100, can score max M1A0A0M0A0	